A Project report on

Huffman Based LZW Lossless Image Compression Using Retinex Algorithm

A Dissertation submitted to JNTU Hyderabad in partial fulfillment of the academic requirements for the award of the degree.

Bachelor of Technology

in

Computer Science and Engineering

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2020- 2024

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CERTIFICATE

This is to certify that the Major Project Phase I report entitled **" Huffman Based LZW Lossless Image Compression Using Retinex Algorithm "** being submitted by K. Nithin (20H51A0513), R. Yeshwanth Raju (20H51A0546), M. Pavan Kumar (20H51A05H6) in partial fulfillment for the award of **Bachelor of Technology in Computer Science and Engineering** is a record of bonafide work carried out his/her under my guidance and supervision.

The results embodies in this project report have not been submitted to any other University or Institute for the award of any Degree.

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ACKNOWLEDGEMENT

With great pleasure we want to take this opportunity to express my heartfelt gratitude to all the people who helped in making this project work a grand success.

We are grateful to **Mr. BK Chinna Maddileti**, Assistant Professor Department of Computer Science and Engineering for his valuable technical suggestions and guidance during the execution of this project work.

We would like to thank **Dr. Siva Skandha Sanagala,** Head of the Department of Computer Science and Engineering, CMR College of Engineering and Technology, who is the major driving forces to complete my project work successfully.

We are very grateful to **Dr. Vijaya Kumar Koppula**, Dean-Academics, CMR College of Engineering and Technology, for his constant support and motivation in carrying out the project work successfully.

We are highly indebted to **Major Dr. V A Narayana,** Principal, CMR College of Engineering and Technology, for giving permission to carry out this project in a successful and fruitful way.

We would like to thank the **Teaching & Non- teaching** staff of Department of Computer Science and Engineering for their co-operation

We express our sincere thanks to **Shri. Ch. Gopal Reddy**, Secretary, CMR Group of Institutions, for his continuous care.

Finally, We extend thanks to our parents who stood behind us at different stages of this Project. We sincerely acknowledge and thank all those who gave support directly and indirectly in completion of this project work.

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ABSTRACT

Image compression is an application of data compression that encodes the original image with few bits. The objective of image compression is to reduce irrelevance and redundancy of the image data in order to be able to store or transmit data in an efficient form. So image compression can reduce the transmit time over the network and increase the speed of transmission. In Lossless image compression no data loss when the compression Technique is done. In this research, a new lossless compression scheme is presented and named as Huffman Based LZW Lossless Image Compression using Retinex Algorithm which consists of three stages: In the first stage, a Huffman coding is used to compress the image. In the second stage all Huffman code words are concatenated together and then compressed with LZW coding and decoding. In the third stage the Retinex algorithm are used on compressed image for enhance the contrast of image and improve the quality of image. This Proposed Technique is used to increase the compression ratio (CR), Peak signal of Noise Ratio (PSNR), and Mean Square Error (MSE) in the MATLAB Software.

CHAPTER 1
INTRODUCTION

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1.1 Problem Statement

The study aims to identify the specific challenges and objectives of this research or project. It is essential for applications that require the faithful reconstruction of the original images. The problem at hand is to develop an efficient and effective image compression method that combines Huffman coding with LZW to achieve lossless compression while integrating the Retinex algorithm for image enhancement.

1.2 Research Objective

A common characteristic of most images is that the neighbouring pixels are correlated and therefore contain redundant information. The foremost task then is to find less correlated representation of the image. Two fundamental components of compression are redundancy and irrelevancy reduction .Redundancies reduction aims at removing duplication from the signal source (image/video). Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver, namely the Human Visual System.

1.3 Project Scope and Limitations

Scope:

- The scope of the project encompasses the development of lossless.
- Image compression method that integrates Huffman coding , LZW compression.
- It includes research, experimentation, evaluation, and may involve the Development of a prototype implementation.
- The primary focus is on improving compression efficiency while enhancing.
- Image quality, with an eye towards real-world applications.

Limitations:

- Large Data Requirements: U-Net models, like many deep learning models, require large amounts of labeled data for training. Gathering and annotating medical images can be a time-consuming and expensive process, and in some cases, there may be limited access to such data due to privacy and legal restrictions.

CHAPTER 2
BACKGROUND WORK

CHAPTER 2
BACKGROUND WORK

2.1 Lossless-JPEG compression method

2.1.1 Introduction

The problem is to develop a lossless image compression method that reduces image file sizes without any loss of image data. The objective is to create a compression technique that can store images more efficiently while enabling exact reconstruction.

2.1.2 Merits

1. Lossless Compression: JPEG-LS is primarily designed for lossless compression, which means it can compress images without any loss of image quality. This makes it suitable for applications where preserving every detail of the image is crucial.

2. Efficient Compression: It often achieves high compression ratios while maintaining lossless quality, making it an effective choice for reducing file sizes of images with minimal degradation.

2.1.3 Demerits

1. Limited Support: JPEG-LS is not as widely supported as other image compression formats, such as JPEG or PNG. This means that it may not be compatible with all software and devices.

2. Complexity: The encoding and decoding processes of JPEG-LS can be more complex compared to some other lossless compression methods. This complexity can result in higher computational requirements and slower processing times.

3. Not Suitable for All Types of Images: JPEG-LS is most effective for images with smooth areas, natural gradients, and fine details. It may not perform as well on images with sharp edges or high-frequency patterns.

Challenges

Lossless JPEG, or JPEG-LS, is a valuable image compression method that maintains image quality while reducing file size. It's well-suited for applications where preserving image fidelity is critical.

2.1.3 Implementation

JPEG-LS was developed with the aim of providing a low-complexity lossless and near-lossless image compression standard that could offer better compression efficiency than lossless JPEG. It was developed because at the time, the Huffman coding-based JPEG lossless standard and other standards were limited in their compression performance. Total decorrelation cannot be achieved by first order entropy of the prediction residuals employed by these inferior standards. JPEG-LS, on the other hand, can obtain good decorrelation. Part 1 of this standard was finalized in 1999. Part 2, released in 2003, introduced extensions such as arithmetic coding.

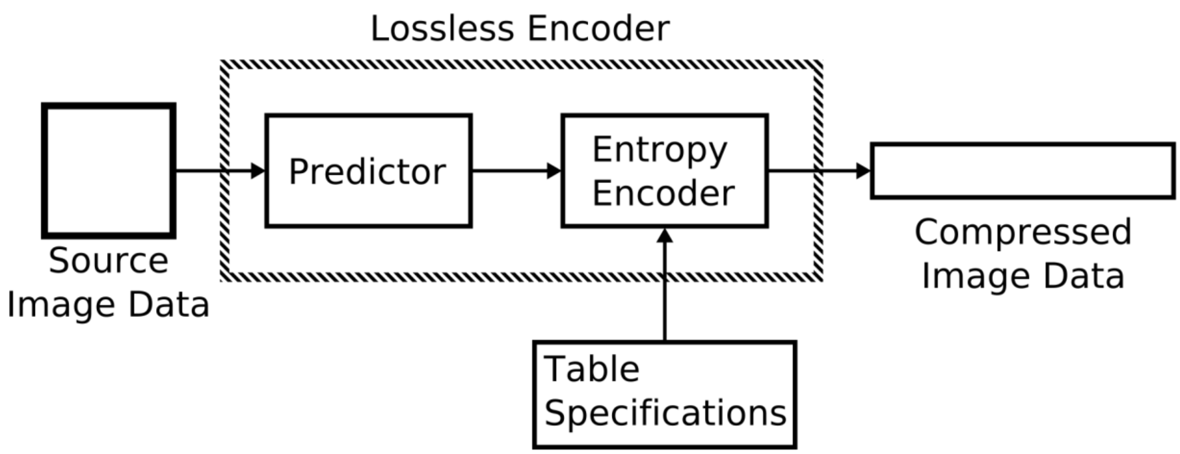

Fig 2.1.3: Lossless-JPEG Compression

2.2 Run-Length Encoding (RLE)

2.2.1 Introduction

Run-Length Encoding (RLE) is a simple form of data compression that is used to reduce the size of files or data by encoding consecutive repeated characters or values as a single value followed by a count. It's often employed in scenarios where there are long sequences of the same data, such as simple graphics, black and white images, or certain types of binary data.

2.2.2 Merits, Demerits and Challenges

Merits:

1. Simplicity: RLE is easy to understand and implement. It's a basic compression technique that doesn't require complex algorithms or substantial computational resources.

2. Fast Encoding and Decoding: Both encoding and decoding operations are typically very fast since they involve straightforward processes of counting and replacing.

3. Efficient for Certain Data: RLE works particularly well with data that has long sequences of repeated values, making it efficient for certain types of data, such as simple graphics or binary data.

Demerits:

1. Inefficient for Complex Data: RLE is not efficient for data with little or no repetitive patterns. In such cases, the compression might not be significant or could even result in larger files.

2. Limited Compression: RLE doesn't offer the same level of compression as more advanced algorithms like ZIP or GZIP. It's not suitable for highly compressible data.

3.Implementation Compatibility: Compatibility issues can arise when transferring RLE-encoded data between different systems or software that may not support RLE.

Challenges:

1. Choosing the Right Threshold: Determining when to use RLE can be challenging. It's critical to identify situations where long runs of the same value exist, and RLE can be beneficial.

2. Lossless vs. Lossy: RLE is typically used for lossless compression, but in some cases, you may have to decide whether to use lossy compression (where some data is sacrificed for greater compression) or lossless RLE.

3. Implementation Compatibility: Compatibility issues can arise when transferring RLE-encoded data between different systems or software that may not support RLE.

2.2.3 Implementation

Run-Length Encoding is a basic compression algorithm that works by replacing sequences of identical values with a single value followed by a count of the number of times that value occurs. For example, the string "AAABBBCCDAA" could be encoded as "3A3B2C1D2A." It's simple to implement and can be useful in scenarios where there are long runs of identical data.

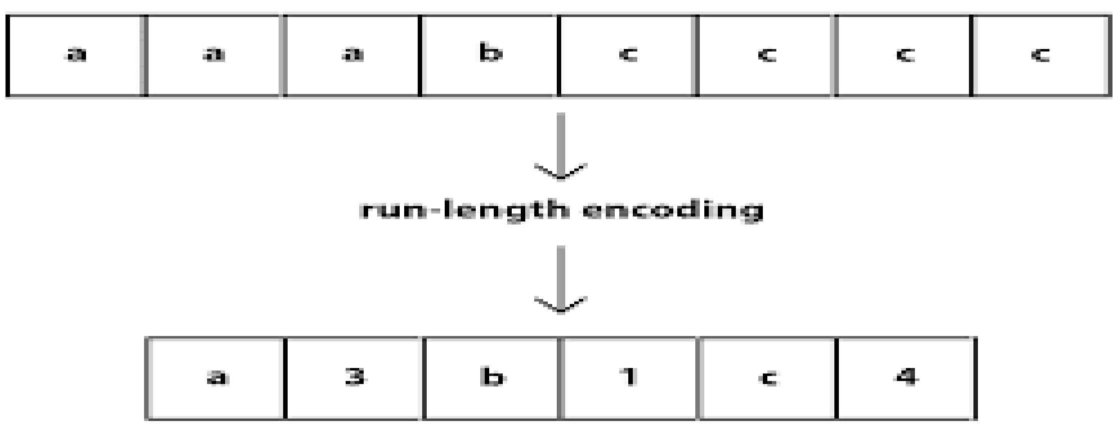

Fig 2.2.3 **Run-Length Encoding (RLE)**

2.3 Wavelet Compression

2.3.1 Introduction

Wavelet compression is a method of data compression that employs wavelet transformations to analyze and reduce the data. It is particularly useful for handling data with varying levels of detail, such as images, audio, and other types of signals. The fundamental idea is to transform the data into a different domain where it can be represented more efficiently. Wavelet compression techniques aim to capture the most important features of the data while discarding redundant or less significant information.

2.3.2 Merits, Demerits and Challenges

Merits:

1. Multi-Resolution Analysis: Wavelet compression supports multi-resolution analysis, which allows it to represent data at different levels of detail. This makes it suitable for compressing data with both fine and coarse features.

2. Good Image Compression: Wavelet compression is commonly used in image compression, and it often outperforms other methods like JPEG in terms of image quality at high compression ratios.

3. Lossless or Lossy Compression: Wavelet compression can be applied in both lossless and lossy modes, giving flexibility depending on the application's requirements.

4. Progressive Transmission: Wavelet compression allows for progressive transmission, meaning that an incomplete compressed image or signal can be viewed, and more detail is added as the transmission continues.

5. Robustness: Wavelet compression is relatively robust to noise and can maintain the quality of the reconstructed data even in the presence of some data corruption.

Demerits:

1. Complexity: Implementing wavelet compression algorithms can be complex and computationally intensive, especially for real-time applications or large datasets.
2. Artifact Generation: In lossy compression, wavelet-based methods can generate compression artifacts, especially at high compression ratios.
3. Non-Uniform Quality: Depending on the chosen wavelet, the quality of compression can be non-uniform across different types of data.
4. Limited to Specific Data Types: Wavelet compression is not a one-size-fits-all solution and may not perform well on all types of data.

Challenges:

1. Choice of Wavelet: Selecting the right wavelet function is critical for achieving optimal compression results. Different types of data may require different wavelets.
2. Parameter Tuning: Many wavelet compression algorithms have various parameters that need to be tuned to optimize compression quality and speed.
3. Data Dependency: Handling data dependencies, especially in video compression, can be a significant challenge.

2.3.3 Implementation

Wavelet compression is a technique used to compress data by employing the mathematical tool of wavelet transform. It's particularly effective in signal and image compression. The fundamental idea behind wavelet compression involves breaking down the data into different frequency components using wavelets, which are small waves of varying frequency and limited duration.

The process typically involves:

Decomposition: The data is decomposed into its high and low-frequency components using a wavelet transform. This step creates a multiresolution representation, where high frequencies (fine details) are separated from the low frequencies (coarse details).

Quantization and Compression: The coefficients obtained from the wavelet transform are quantized, and the less important coefficients (usually smaller in magnitude) are discarded or set to zero. This reduction in data results in compression.

Reconstruction: The compressed data is then reconstructed by applying the inverse wavelet transform. This process allows the approximate original data to be reconstructed, often with some loss of fine details that were discarded during compression.

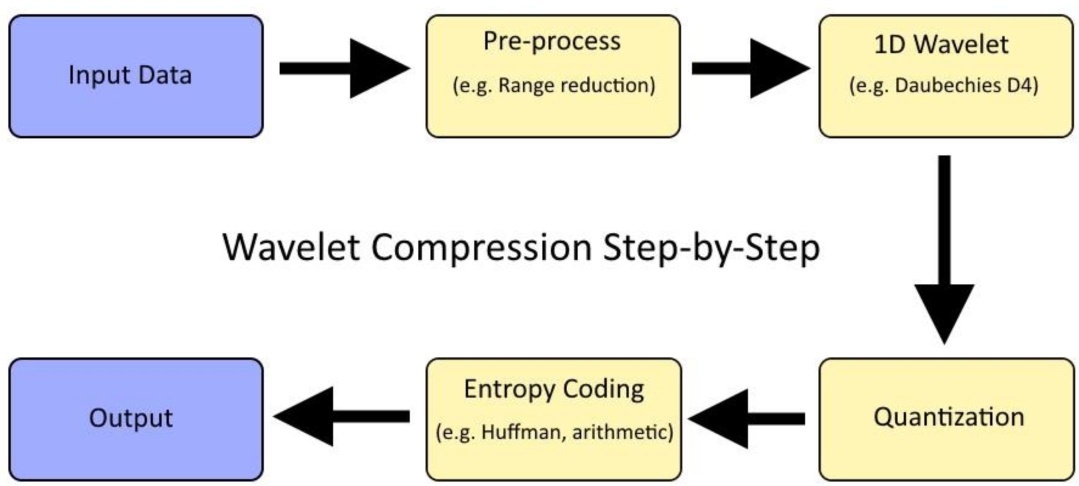

Fig 2.3.3: Wavelet Compression

CHAPTER 3
RESULTS AND DISCUSSION

CHAPTER 3

RESULTS AND DISCUSSION

- Using Huffman coding, LZW (Lempel-Ziv-Welch) compression, and the Retinex algorithm for image processing can provide effective lossless image compression with enhanced image quality.
- The Retinex algorithm is applied for image enhancement. Retinex is a color and brightness perception model that aims to improve the visual appearance of images by enhancing details, reducing shadows, and correcting for uneven illumination.
- Finally the combination of Huffman and LZW compression, along with the Retinex enhancement, ensures that you achieve high compression efficiency without compromising image quality.

CHAPTER 4
CONCLUSION

CHAPTER 4

CONCLUSION

Compression is a topic of much importance and many applications. This thesis presents the lossless image compression on different images. Different algorithms have been evaluated in terms of the amount of compression they provide, algorithm efficiency, and susceptibility to error. While algorithm efficiency and susceptibility to error are relatively independent of the characteristics of the source ensemble, the amount of compression achieved depends upon the characteristics of the source to a great extent. It is concluded that the higher data redundancy helps to achieve more compression. Reproduced image and the original image are equal in quality by using Retinex Algorithm, as it enhances the image contrast using MSR.

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Github Link: